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Environmental Factors and Efficacy of Castor Seed Influencing Aedes aegypti Larval Presence

Indra Chahaya[1]✉, Winni R E Tumanggor[1], Lanova Dwi Arde[1], Khairunnisa[2], Najwa Shadrina[1], Lyra Caroline D Purba[1]

[1]Faculty of Public Health, Universitas Sumatera Utara, Medan, Indonesia
[2]Facultas of Pharmacy, Universitas Sumatera Utara, Medan, Indonesia

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Abstract

Dengue hemorrhagic fever (DHF) is a major global health challenge, especially in areas endemic to the *Aedes aegypti* mosquito. This study analyzes the environmental factors influencing larval presence and investigates the effectiveness of natural larvicides from castor seed (*Ricinus communis*) in controlling *Ae. aegypti* mosquito larvae. A cross-sectional survey of households by purposive sampling between those located near and far from public places, and a quasi-experimental study comparing households in the intervention group (using castor seed powder larvicide) with those in the comparison group (not using castor seed powder larvicide) were conducted in Medan Amplas District, Medan City. The study found that location significantly impacts mosquito larvae ($p = 0.045$, OR 3.26, 95% CI), with households near public places at higher risk. Applying castor seed-based natural larvicide at 100 mg/L of water ($p = 0.0001$, OR 37.76, 95% CI 17.9-79.2) significantly reduced larvae, with a 37.76-fold higher likelihood of larval absence than the comparison group. Notably, the use of castor seed powder demonstrated exceptional effectiveness in reducing the presence of *Ae. aegypti* mosquito larvae. These findings highlight the potential of castor seed natural larvicides as a sustainable and environmentally friendly alternative to chemical larvicides, particularly for households near public places.

Introduction

Dengue hemorrhagic fever (DHF) is a severe case of dengue fever that can be fatal. It is caused by the dengue virus spread by the *Aedes aegypti* mosquito. Currently, cases of DHF occur in more than 100 countries in regions recognized by the World Health Organization (WHO), which include Africa, the Americas, the Eastern Mediterranean, Southeast Asia, and the Western Pacific. The regions most severely affected by DHF are the Americas, Southeast Asia, and the Western Pacific, with Asia contributing to approximately 70% of the global disease burden (World Health Organization, 2023).

Based on primary DHF data from the Ministry of Health of the Republic of Indonesia, the number of DHF cases in 2020 amounted to 103,509. Meanwhile, the number of DHF-related fatalities in the same year was 725 victims, with a case fatality rate (CFR) of 0.70% and an incidence rate (IR) of 38.15% per 100,000 population (Ministry of Health of the Republic of Indonesia, 2021). Dengue fever cases occur in nearly every region of Indonesia, including North Sumatra. The incidence rate of DHF has experienced consecutive declines from 2019 to 2021. In 2019, the DHF incidence rate was 53.09 per 100,000 population. The CFR of DHF in 2020 was 0.2%, a reduction from the 0.3% CFR in 2019. In Medan, one of the municipalities in the province of North Sumatra, the number of DHF cases, based on data from the Central Statistics Agency for

✉ Correspondence Address:
Faculty of Public Health, Universitas Sumatera Utara, Medan, Indonesia
Email: indra4@usu.ac.id

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2020, amounted to 1,068 cases (Ministry of Health of the Republic of Indonesia, 2022).

Research conducted by Baskoro *et al.* (2017) in Yogyakarta, Indonesia, showed that various physical environmental variables influenced the number of dengue vector mosquitoes, the condition of the houses, occupancy density, and vegetation (Baskoro *et al.*, 2017). Female *Aedes aegypti* mosquitoes select freshwater breeding sites near human settlements, as high salinity is fatal to their offspring, making water purity a key factor in oviposition (Matthews *et al.*, 2019). Water storage containers, especially crocks, were identified as the primary breeding habitat for *Ae. aegypti* larvae. In addition, factors such as the use of bed canopies, unemployment, the volume of water storage, and the interaction between the amount of garbage collected and rainfall two weeks before sampling were positively correlated with larvae (Ha *et al.*, 2021; Ferede *et al.*, 2018; Vannavong *et al.*, 2017).

Governments globally employ an Integrated Mosquito Management (IMM) approach to control mosquitoes. Monitoring mosquito breeding sites can significantly reduce mosquito populations within communities (Centers for Diseases Control and Prevention, 2022). Professionals engage in mosquito control by monitoring mosquito populations, eliminating mosquito breeding sites (Centers for Diseases Control and Prevention, 2022; World Health Organization, 2023), managing mosquito larvae and pupae, controlling adult mosquitoes, and monitoring mosquito control efforts (World Health Organization, 2017).

The rapid reproduction from the larval stage to adult mosquitoes highlights the critical need for mosquito larval control efforts (Evans *et al.*, 2023; Linenberg *et al.*, 2016). By focusing on the early stages, larval source management (LSM) plays a crucial role in integrated mosquito control programs (Dusfour & Chaney, 2022). In addition to the methods mentioned earlier, another known approach is using larvicides, which can be chemical or natural. The most well-known chemical larvicide to the general public is temephos. However, the long-term use of temephos has led to mosquito larvae developing resistance to this larvicide (Adhikari & Khanikor, 2021; Piedra *et al.*, 2024; Bellinato *et al.*, 2016). According to a study conducted by Adhikari & Khanikor (2021) in India, temephos exhibited a dose-dependent effect, with larval mortality rates changing as the number of generations increased. At a concentration of 2 ppm, larval mortality remained at 100% until the 9th filial generation but gradually declined to only 22.66% by the 28th filial generation. The LC50 value of temephos initially showed a decreasing trend up to the 9th filial generation. However, by the 28th filial generation, the LC50 value had increased by 7.83-fold. Temephos resistance is also a global issue, specifically in Peru. Research conducted by Palomino *et al.* in 2022 indicates that out of 39 field populations of *Ae. aegypti* tested for temephos resistance, 11 exhibited high resistance levels with a resistance ratio (RR) exceeding 10 (Palomino *et al.*, 2022).

Suppose the continuous increase in the usage dosage of temephos occurs without implementing a new insecticide replacement program. In that case, it harms public health and the environment. Furthermore, temephos can also endanger non-target animals (Satriawan *et al.*, 2019). There is a need for alternative solutions in larvicide usage to reduce these larvae (Prabakaran *et al.*, 2017). Many researchers are increasingly conducting experiments with natural larvicides(de Souza *et al.*, 2019; Milugo *et al.*, 2021; Wahyuni *et al.*, 2019). From the research on the use of natural larvicides from red ginger extract, the higher the concentration of extract used, the greater the mortality rate of *Ae. aegypti* larvae. The highest mortality rate was recorded at a 100% concentration, while the lowest was observed at 60%. These results remained consistent after five repetitions, with each repetition lasting for 24 hours (Boekoesoe & Ahmad, 2022). The combination of papaya leaf juice and hay infusion can also serve as both an attractant and a bioinsecticide against *Ae. aegypti* mosquitoes (Cahyati *et al.*, 2017).

Plants naturally produce chemical compounds to defend against pathogenic microorganisms and insects. These biologically active chemical compounds, known as 'phytochemicals,' serve as repellents, toxins, feeding deterrents, and growth regulators against insects (Bekele, 2018; Demirak & Canpolat, 2022; Gajger & Dar, 2021). Natural larvicides have proven to be effective in killing *Ae. aegypti* mosquito larvae include essential oils, saponins, and flavonoids (Sanei-Dehkordi *et al.*, 2024; Wahyuni *et al.*, 2019). A literature review conducted by Pavela *et al.* (2019) identified 29 plant extracts that have proven effective as natural mosquito larvicides, including castor seed (*Ricinus communis*), in eradicating *Ae. aegypti* larvae (Pavela *et al.*, 2019). *Ricinus communis*, commonly known as castor seed or oil plant, belongs to the *Euphorbiaceae* family, *Ricinus* genus, and *Ricinae* tribe. This widespread plant can be found worldwide in tropical, subtropical, and warm-climate areas (Patel *et al.*, 2016; Subramaniyan, 2020). *Ricinus communis* also exhibits robust adaptability to different weather conditions, with a critical characteristic being its ability to thrive in marginal soils (Osorio-González *et al.*, 2020). Building upon prior findings that suggest castor seed extracts are more potent in mosquito eradication (Wamaket *et al.*, 2018). This research aims to explore castor seeds' potential as agents for reducing *Ae. aegypti* mosquito larvae.

Castor seed extract also contains ricin compounds, a natural toxin found in castor seeds that can be powder, mist, pellets, dissolved in water, or weak acid (Centers for Disease Control and Prevention, 2018). Extracts from the leaves and seeds of *Ricinus communis* have been shown to kill *Ae. aegypti* mosquito larvae, with seed extracts being more effective than leaf extracts. Castor seed extract has also been used for non-target organisms, such as Guppy fish, as it did not exhibit significant effects after 24 or 48 hours of exposure at LC50 and LC90 values (Sogan *et al.*, 2018). The objectives of this study were to analyse environmental factors affecting the presence of larvae and the effectiveness of natural larvicides derived from castor seed in reducing the presence of *Ae. aegypti* mosquito larvae.

Method

This study used two design approaches. Namely, cross-sectional and experimental. Environmental variables and larval presence were measured comprehensively through a cross-sectional design, while the effectiveness of the intervention was tested through a quasi-experimental design. The population for this research comprised all households in the Medan Amplas District, totaling 29,461 households. A sample size of 260 households was selected using purposive sampling. Of these, 130 were far away, and 130 were near public places. For the quasi-experiment, 130 households were assigned to the intervention group and 130 to the comparison group. The intervention group received the application of castor seed powder at a concentration of 100 mg/L of water in households. Data collection methods employed in this study included observation sheets and questionnaires.

The independent variables in this research were the application of castor seed larvicide using ovitraps and environmental conditions, which consist of location (proximity to public facilities), house type, housing density, the presence of ventilation, habits regarding ventilation opening, the presence of wire mesh on ventilation openings, unused goods stacking, the presence of hanging clothes, the practice of draining water containers, and the practice of covering water containers. The dependent variable in this research was the presence of *Ae. aegypti* mosquito larvae in containers. Data analysis for the variables was conducted using the Chi-Square test, logistic regression, and McNemar at a significance level of 5%. During the research, the enumerator team was equipped with informed consent forms as part of the ethical clearance documentation issued by the Health Research Ethics Committee of Universitas Sumatera Utara, with reference number 937/KEPK/USU/2023.

The measured variables in the cross-sectional design include dependent and independent variables. The dependent variable was the presence of larvae measured indoors and outdoors using a flashlight to detect the presence of larvae in each water container. The independent variables consisted of environmental variables that encompassed several aspects. Firstly, location variables were divided into near and far from public places. This category was determined based on public areas throughout the location, such as schools, markets, and health centers. Secondly, house types were divided into permanent and non-permanent. Permanent houses had brick walls, cement or ceramic floors, and tiled roofs, while non-permanent houses had wooden or bamboo walls, dirt floors, and zinc or asbestos roofs.

Furthermore, house density was measured based on the number of family members living in one house. If there is more than one householder in a home or the living area per person is less than 9 m^2, the house is categorized as overcrowded. Otherwise, it is classified as non-overcrowded if it is below these limits. Ventilation was measured by categorizing the presence or absence of ventilation (windows and vents). Wire mesh presence is measured by whether or not there is wire mesh in the house's ventilation. Opening of ventilation was measured as yes or no, which determined whether ventilation (including windows) was opened or closed at all times. Then, the stacking of unused goods was measured by the category of their presence or absence in the house. Hanging clothes was measured by whether clothes were hung in the house or not. Furthermore, covering the water container was measured by whether the water storage container was closed or not. The draining water container variable was measured by whether each water container was drained or not. If it is done once a week, it is categorized as draining, but if it is not done accordingly, it is classified as not draining.

In the experimental design, the intervention group applied castor seed powder at a concentration of 100 mg/L of water using ovitraps, while the comparison group used ovitraps filled with water only. Chahaya *et al.* (2024) previously studied this dosage in Medan City and found it to be the most effective in reducing the presence of the larvae (Chahaya *et al.*, 2024). The use of ovitraps is also effective for *Ae. aegypti* mosquitoes to lay eggs consistent with research conducted by Cahyati & Siyam, (2019) in Semarang, which showed that the most preferred containers for the mosquitoes to lay eggs were the ones made of plastic and metal. Measurements in both groups on day 0 (pre-treatment) and day 7 (post-treatment) to assess the effectiveness of the larvicide in reducing the presence of larvae (Cahyati & Siyam, 2019). Data analysis was conducted in several stages. In the cross-sectional study, the chi-square test was first used to assess the effect of environmental variables on the presence of *the* larvae. Next, logistic regression was performed to identify the environmental variables that most significantly influenced larvae's presence. In the quasi-experimental analysis, the chi-square and McNemar tests were used to evaluate the effectiveness of applying castor bean larvicide with ovitraps. These tests compared pre-treatment and post-treatment results to assess significant changes in the larval population following the intervention.

Result and Discussion

Table 1 presents the findings to identify environmental factors associated with larval presence. Out of 260 houses, the presence of *Ae. aegypti* larvae were highest in houses near public places, with 126 houses (96.9%). Additionally, most larvae were found in permanent houses, totaling 212 houses (92.6%), particularly in houses with a lower population density, where the presence of larvae was highest in 175 houses (94.6%). Moreover, houses with ventilation systems exhibited the highest larval presence, with 234 houses (93.2%), and among these, houses lacking wire mesh on the ventilation had a higher larval presence, with 169 houses (91.8%). Furthermore, among houses with ventilation, those that kept the ventilation open throughout the day showed a higher presence of larvae, with 147 houses (91.9%). In households with a significant accumulation of unused goods, the presence of larvae was more pronounced, occurring in 124 houses (89.9%). Households where clothes were not hung tended to have a higher presence of larvae, with 133 houses (93.7%). Regarding the implementation of draining and covering the water containers, houses that did not cover water containers had a higher presence of larvae, totaling 227 houses (93.4%). However, houses that had properly drained water containers had a higher presence of larvae, with 182 houses (92.9%). A significant association was observed between larval presence and both locations (p=0.045) and unused goods stacking (p=0.001).

TABLE 1. Environmental Factors Associated with Larvae's Presence

Variables	Presence of Ae. aegypti larvae		OR	95 % CI	P value
	Available	Not available			
	n (%)	n (%)			
Location					
Near public places	126 (96.9)	4 (3.1)	3.50	1.11 to 11.03	0.045*
Far from public places	117 (90.0)	13 (10.0)			
House Types					
Non-permanent	31 (100.0)	0 (0.0)	1.08	1.08 to 1.12	0.236
Permanent	212 (92.6)	17 (7.4)			
Housing Density					
Overcrowded	68 (90.7)	7 (9.3)	0.55	0.20 to 1.51	0.272
Not overcrowded	175 (94.6)	10 (5.4)			
Ventilation Presence					
Not available	9 (100.0)	0 (0.0)	1.07	1.03 to 1.10	1.000
Available	234 (93.2)	17 (6.8)			
Wire Mesh Presence					
Not available	169 (91.8)	15 (8.2)	0.30	0.06 to 1.36	0.148
Available	74 (97.4)	2 (2.6)			
Opening Ventilation					
Yes	147 (91.9)	13 (8.1)	0.47	0.14 to 1.48	0.385
No	87 (96.0)	4 (4.0)			
Unused Goods Stacking					
Available	124 (89.9)	14 (10.1)	0.22	0.06 to 0.79	0.001*
Not available	119 (97.5)	3 (2.5)			
Hanging clothes					
Available	110 (93.2)	8 (6.8)	0.93	0.34 to 2.49	1.000
Not available	133 (93.7)	9 (6.3)			
Covering water containers					
No	227 (93.4)	16 (6.6)	0.88	0.11 to 7.11	1.000
Yes	16 (94.1)	1 (5.9)			
Draining water containers					
No	61 (95.3)	3 (4.7)	1.56	0.43 to 5.62	0.771
Yes	182 (92.9)	14 (7.1)			

*Significant

TABLE 2. Logistic Regression Model 1 and Model 2

Model 1			Model 2		
Variables	**OR (95% CI)**	**P value**	**Variables**	**OR (95% CI)**	**P value**
Location	3.15 (0.98 to 10.0)	0.053	Location	3.26 (1.0 to10.3)	0.045
Unused Goods Stacking	0.25 (0.07 to 0.9)	0.037	Unused Goods Stacking	0.24 (0.06 to 0.85)	0.028
Wire Mesh Presence	0.38 (0.08 to 1.7)	0.210			

TABLE 3. Comparison of Larvae's Presence Between the Intervention and Comparison Groups

Variables		Presence of Ae. aegypti larvae		OR	95% CI	P value
		Available	Not available			
		n (%)	n (%)			
Day-0	Comparison group	123 (47.3)	7 (2.7)	1.46	0.54 to 3.97	0.616
	Intervension group	120 (46.2)	10 (3.8)			
Day-7	Comparison group	119 (45.8)	11 (4.2)	37.76	17.92 to 79.20	0.0001
	Intervension group	29 (11.2)	101 (38.8)			

TABLE 4. Comparison of larvae's presence on day 0 and day 7 in each group

Groups	Presence of Ae. Aegypti larvae (Day-0)	Presence of Ae. aegypti larvae (Day-7)			P value
		Available	Not available	Total	
		n	n	n	
Comparison group	Available	118	5	123	0.219
	Not available	1	6	7	
	Total	119	11	130	
Intervention group	Available	26	94	120	0.0001
	Not available	3	7	10	
	Total	29	101	130	

Table 2 presents the results of the multivariate analysis. The significance of the location variable after removing the wire mesh variable was 0.045, which means that the location and accumulation of goods affect the number of larvae. So people who live near public places have a 3.26 times greater number of larvae than those who live far from public places. Table 3 shows that on day 0, the presence of *Ae. aegypti* larvae were 94.6% in the comparison group and 92.3% in the intervention group (p-value=0.616), demonstrating no significant difference between the two groups at the outset. However, by day 7, the comparison group had 119 larvae (45.8%), while the treatment group had only 29 (11.2%). The significant difference in larval presence between the comparison and intervention groups (p=0.0001) suggests that the comparison group was 37.76 times more likely to harbor larvae than the intervention group. Table 4 presents the analysis result using the McNemar test. In the comparison group, there were 118 houses with *Ae. aegypti* larvae on both day 0 and day 7. In the group receiving the natural larvicide treatment, there were 94 houses with mosquito larvae presence, but not after the treatment. The application of natural larvicide, specifically using 100 mg of castor seed powder per liter of water, has been proven effective in reducing the presence of *the* mosquito larvae, with a p-value of 0.0001.

Environmental factors can influence the presence of *Ae. aegypti* mosquito larvae (Baskoro *et al*., 2017). Table 1 presents the study's results, indicating that the variables affecting the presence of the larvae are located, and households accumulate unused goods. Houses near public places or in densely populated areas have a higher risk of increased mosquito density (Louis *et al*., 2016). Urban environments provide abundant habitats that support the proliferation of *Aedes aegypti*, while high human population densities can contribute to significant outbreaks of mosquito-borne diseases (Lindsay *et al*., 2017). *Ae. aegypti* mosquitoes have several characteristics and habits that make them more adaptive in densely populated urban environments (Ndenga *et al*., 2017; Herath *et al*., 2024). Research in Jakarta, Indonesia, by Hamid *et al.* (2017) also notes *Ae. aegypti* mosquitoes exhibit hematophagy behavior, actively seeking blood hosts, especially humans, during daylight hours (Hamid *et al*., 2017). This behavior exposes *Ae. aegypti* mosquitoes to humans in densely populated urban environments where human activity is intense during the day.

The findings of this study show that houses far from public areas have a 3.26 times greater tendency not to have larvae than houses near public places. This research is consistent with Louis' (2016) finding that schools, workplaces, and other public places contain 2.77 times more larvae and pupae than residential areas (95% CI) (Louis *et al*., 2016). Research conducted in the Ivory Coast, West Africa, by Zahouli *et al*. (2016) also showed the highest average number of *Ae. aegypti* was found in urban areas, precisely 1.97 ± 0.10 *Ae. aegypti*/ovitrap/week, with significantly lower average numbers found in rural and suburban areas, at 0.57 ± 0.05 and 1.20 ± 0.09 *Ae. aegypti*/ovitrap/week, respectively (Zahouli *et al*., 2016).

In addition to location, this study also suggests that the habit of piling up unused goods can create breeding grounds for mosquitoes. The analysis results reveal a significant difference in the presence of larvae between households with and without piling up unused goods (p-value=0.024). This considerable difference underscores the importance of human habits in mosquito breeding. One of the main factors contributing to mosquito proliferation in a location is poor hygiene in the home environment (Olagunju, 2023). Forsyth *et al*. (2020) conducted relevant research investigating the effect of unused goods accumulation in creating an environment conducive to mosquito breeding (Forsyth *et al*., 2020). The habit of accumulating unused goods (Samsudin *et al*., 2024), especially goods that can hold water, such as containers, flower pots, buckets, and similar objects, creates ideal conditions for *Ae. aegypti* mosquitoes to lay eggs and breed (Viswan *et al*., 2020; Newyearsi & Silviana, 2022). Research conducted in Kenya by Forsyth *et al.* (2020) revealed that the most productive mosquito breeding sites could be categorized into three groups: 1) containers with a direct or reusable purpose (e.g., buckets); 2) containers without a direct purpose but possessing reusable value (e.g., tires); and 3) containers with no direct purpose and limited reusable value. Therefore, vector control efforts to reduce container abundance and potential mosquito breeding habitats should be prioritized (Forsyth *et al*., 2020).

Despite the emphasis on environmental controls, natural larvicides have also proven effective in controlling mosquito populations. When applied to the intervention group, these larvicides resulted in slower larval movement, tremors, convulsions, and mortality (De Azevedo *et al*., 2021). The study reveals a significant difference (p=0.0001) in larvae presence between the comparison and intervention groups, with the comparison group having a 37.76 times higher likelihood of having larvae. So, the application of natural larvicides, specifically castor seed powder, at a dose of 100 mg per liter of water.

The percentage of larval mortality at various concentrations of castor oil is dose-dependent, with higher concentrations resulting in more significant larval mortality (Wamaket *et al*., 2018). The findings of a previous study conducted by Chahaya *et al.* (2024) in Medan City, North Sumatra, indicate that a dosage of castor seed larvicide at 100 mg/L is the most effective compared to other tested dosages

(Chahaya *et al*., 2024). This dosage significantly reduces the number of larvae, as evidenced by the comparison between the intervention group, which received the treatment, and the control group, which did not. The aqueous extract of *Ricinus communis* was found to have a highly detrimental larvicidal effect on *Culex pipiens* mosquitoes, causing 50% larval mortality in less than 6 hours for the second instar stage and less than 12 hours for the first instar stage (Rihane & Mellouki, 2017). Research conducted by Wachira *et al*. (2014) found that extracts from *Tithonia diversifolia* and *Ricinus communis* were the most toxic to adult female *Anopheles gambiae* mosquitoes compared to the other four test plants after a 7-day treatment, with LC50 values of 1.52 and 2.56 mg/mL, respectively (Wachira *et al*., 2014). Additionally, *Ricinus communis* and nanoparticles prepared as substitutes for chemical pesticides were highly effective against vector-linked mosquitoes (Waris *et al*., 2020).

Ricinus communis has a high percentage of monounsaturated fatty acids and is similar to other vegetable oils. Phytochemical compounds include flavonoids, cyanogenic glycosides, saponins, oxalates, phytates, alkaloids, and tannins (Yeboah *et al*., 2021). Saponins are naturally occurring compounds with diverse structural and chemical properties, widely found in various plant species. Their amphipathic nature, resulting from hydrophilic sugar moieties attached to lipophilic aglycones, grants them multiple biological and functional applications. Saponins are recognized for their foaming, emulsifying, and stabilizing properties, making them valuable in various formulations. Additionally, they exhibit bioactive characteristics, such as anti-inflammatory, antimicrobial, antiviral, anticancer, and immune-modulating effects (Timilsena *et al*., 2023). Alkaloids are organic compounds with basic properties that are widely found in plants and exhibit various biological activities in the body. These compounds play a role in regulating the nervous system and physiological responses through the inhibition of muscarinic acetylcholine receptors and also function as natural insecticides that disrupt the nervous system of insects, making them effective for pest control (Debnath *et al*., 2018).

The effectiveness of larvicide derived from *Ricinus communis* depends on controlling favorable environmental factors. In line with this study, one crucial aspect to consider is the proximity of residences to public spaces. Dwellings close to public areas, such as markets or shopping centers, are likelier to exhibit a heightened risk of disease transmission facilitated by *Ae. aegypti* (Louis *et al*., 2016). Therefore, it is essential to develop a control strategy that accounts for mosquitoes' dispersal patterns based on geographical location. Stacking habits can also impact the efficacy of control measures. Accumulated unused goods around the residence can provide an ideal breeding ground for mosquitoes, especially if they can collect rainwater (Newyearsi & Silviana, 2022). Implementing hygiene policies around the home, such as maintaining a clean yard and disposing of unused items, can significantly reduce breeding grounds for *Ae. aegypti* larvae (Praveen *et al*., 2017). If concurrent environmental control measures do not combine with castor seed larvicide usage, its effectiveness may be significantly reduced. In contrast, castor seed larvicide can decrease *Ae. aegypti* larvae in specific areas, mosquitoes may continue to reproduce in other locations not covered by the larvicide. Conversely, solely managing environmental factors without applying larvicides may not effectively address the mosquito population, as the existing larvae are not directly targeted.

Conclusion

Environmental factors, including the location of households and the accumulation of unused goods, have been identified as significant influences on the presence of these mosquitoes. The use of castor seed larvicide at a concentration of 100 mg/l of water via ovitraps has proven to be an effective method for reducing the presence of *Ae. aegypti* larvae. This study offers insights into a sustainable and environmentally friendly approach to mosquito control, particularly in high-risk areas for dengue transmission, such as household locations near public places. Future research should focus on assessing long-term impacts and exploring the integration of castor seed larvicide into comprehensive vector management programs.

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